

**Appendix F**  
**Risk Assessment Discussion and Calculations**

## **Risk Assessment Discussion and Calculations**

To evaluate the human health risks associated with the various deep soil residual impacts, post demolition risk assessment calculations were performed to supplement the initial post-demolition risk assessment (Integrated 2000). The following additional potential exposure pathways were evaluated for risk assessment calculations after incorporating the January 2001 investigation results:

- inhalation of VOCs in indoor air from upward VOC vapor migration from deep soil into onsite buildings
- inhalation of VOCs in indoor air from upward VOC vapor migration from groundwater into onsite buildings
- inhalation of VOCs in indoor air due to VOC migration from deep soil leachate migration to groundwater and subsequent VOC vapor migration from groundwater into indoor air

Potential further degradation of groundwater due to VOC leaching from soil to groundwater was also evaluated.

The results of the additional risk assessment and the groundwater protection assessment activities are presented below.

### **INHALATION OF INDOOR AIR – VOC VAPOR MIGRATION FROM SOIL INTO INDOOR AIR (INCLUDING SOIL IMPACTS DEEPER THAN 25 FEET BGS)**

The highest previously estimated excess lifetime cancer risk and hazard index associated with potential exposure by the onsite commercial/industrial worker to chloroform from vapor migration into indoor air, as presented in the post-demolition risk assessment, is  $4.25 \times 10^{-10}$  and 0.0000069, respectively. These values are based on an estimated 95 percent upper confidence limit (95% UCL) concentration of chloroform. Since the chloroform concentrations detected during the January 2001 investigation activities are less than the highest concentration reported during the June/July 1999 investigation activities, an estimated 95% UCL concentration for chloroform after incorporating the January 2001 data would be less than the previously estimated 95% UCL concentration. Thus, the associated estimated excess lifetime cancer risk and hazard index after incorporating the January 2001 investigation results would be less than the previously estimated values.

An estimated excess lifetime cancer risk was calculated for possible methylene chloride vapor migration into indoor air for the onsite commercial/industrial worker using the County of San Diego Department of Environmental Health (DEH) vapor migration model and input parameter values presented in the post-demolition risk assessment. The DEH model has been approved by the RWQCB and the OEHHHA for use during the proposed Parcel C risk assessments. The model results, presented in Appendix G, indicate that the estimated excess

lifetime cancer risk and hazard index for possible methylene chloride vapor migration into indoor air is  $3.0 \times 10^{-10}$  and 0.0000022, respectively. Adding the previously estimated risk for VOC migration into indoor air to the estimated risk for methylene chloride results in a risk of  $7.7 \times 10^{-10}$ . This risk estimate is approximately 13,000 times less of the OEHHA-approved acceptable risk level of  $1 \times 10^{-5}$ .

#### **INHALATION OF INDOOR AIR – VOC VAPOR MIGRATION FROM GROUNDWATER INTO INDOOR AIR**

As previously indicated no source of chlorinated VOCs originating from the subject parcel has been identified. Assuming that the VOC source in soil is attributed to VOC migration from groundwater, it is assumed that the estimated risk associated with upward VOC migration from groundwater provides an estimate of the risk associated with upward VOC migration from impacted soil.

Excess lifetime cancer risk and hazard index associated with the vapor migration pathway for the onsite commercial/industrial worker were estimated using the DEH vapor migration model and the highest chloroform, PCE, and methylene chloride concentrations in groundwater obtained from either the most recent samples collected from groundwater monitoring well XMW-09, situated on the subject parcel, or downgradient monitoring wells TMW-11 through TMW-14. The model results are presented in Appendix G, and a summary of the results is presented in Table F-1.

As shown in Table F-1, both the estimated excess cancer risk and estimated hazard index are orders of magnitude less than the risk thresholds of  $1.0 \times 10^{-5}$  and 1.0, respectively. Thus, the existing chloroform and PCE concentrations in groundwater beneath the southern portion of the subject parcel do not pose an indoor air health risk greater than acceptable risk levels.

#### **Groundwater Quality Impact Assessment**

The objective of the groundwater protection assessment is to evaluate whether existing chemical concentrations in onsite soils have the potential to degrade existing groundwater quality. Even though shallow groundwater beneath and in proximity to subject parcel is not used as a domestic water supply, the RWQCB requested, as a conservative measure, that an evaluation be conducted of potential downward chemical migration from soil resulting in possible degradation of the Bellflower aquitard, the most shallow water-bearing zone. The estimated chemical concentrations in groundwater were compared to California drinking water standards, specifically MCLs. This evaluation conservatively and unrealistically assumes that the Bellflower aquitard is a part of the underlying aquifers providing domestic water supply. As described below, the assessment was conducted assuming a conservative scenario regarding chemical migration and mixing in groundwater following approved EPA and RWQCB methodology and assumptions.

The maximum compound of potential concern (COPC) concentrations in soil were compared to site-specific soil screening levels (SSLs) derived from primary or secondary MCLs. Initial

site-specific SSLs were derived using the following formula presented in Section 2.5 of the EPA document entitled *Soil Screening Guidance: Technical Background Document (TBD)*, dated July 1996:

$$\text{Initial SSL} = \text{MCL} [(K_{oc} * f_{oc}) + ((O_w + O_a * H')/P_b)] \quad (\text{Equation 1})$$

Where:

Initial SSL = soil screening level, mg/kg;  
MCL = maximum contaminant level, mg/L;  
 $K_{oc}$  = soil organic carbon-water partition coefficient, L/kg;  
 $f_{oc}$  = organic carbon content of soil, kg/kg;  
 $O_w$  = water-filled soil porosity,  $L_{\text{water}}/L_{\text{soil}}$ ;  
 $O_a$  = air-filled soil porosity,  $L_{\text{air}}/L_{\text{soil}}$ ;  
 $H'$  = Henry's law constant, dimensionless; and  
 $P_b$  = dry soil bulk density, kg/L.

Site-specific geotechnical parameters are presented in Table F-2. The above equation is a partitioning formula, which does not account for chemical attenuation during migration in soil or mixing with groundwater. To better represent contaminant migration in the soil column, an attenuation factor of 3 was applied to the initial SSLs for chloroform, PCE, and methylene chloride. This attenuation factor was obtained from T5-14: Average Attenuation Factor for Different Distance above Ground Water and Lithology presented in the LARWQCB's May 1996 *Interim Site Assessment & Cleanup Guidebook* (the Guidebook), assuming site-specific average soil particle size distributions of 34 percent sand, 54 percent silt, and 13 percent clay (Table F-3), and a distance of 40 feet from soil impacts to the groundwater table. This distance is considered to be appropriate because the depth to groundwater at the site is approximately 65 feet bgs, and the maximum COPC concentrations were detected at approximately 25 feet bgs.

An EPA default dilution attenuation factor (DAF) of 20 was applied to the initial SSL to account for limited groundwater mixing. This EPA default value is presented in the above-referenced July 1996 EPA document, and was used by EPA to develop generic SSLs. The resulting site-specific SSL is equal to the initial SSL (assuming no soil attenuation or groundwater mixing) multiplied by the product of a soil attenuation factor (e.g. 3) and a groundwater mixing factor of 20.

The calculation of site-specific SSLs for COPCs that have promulgated MCLs is presented in Table F-4. A comparison of the calculated site-specific SSLs with the maximum COPC concentrations in soil is also presented in Table F-4.

The maximum chemical concentrations in onsite soil do not exceed the site-specific groundwater protection concentrations (i.e., site-specific SSLs). Thus, chemical concentrations in vadose soils beneath the subject parcel do not pose a threat to groundwater quality via leaching from soil to groundwater.

## **INHALATION OF INDOOR AIR – VOC MIGRATION FROM SOIL LEACHATE MIGRATION TO GROUNDWATER AND SUBSEQUENT VOC VAPOR MIGRATION FROM GROUNDWATER INTO INDOOR AIR**

VOCs in soil may leach into groundwater and subsequently volatilize from groundwater and, through upward diffusion, migrate through the soil column into indoor air. A simple comparison between estimated maximum VOC concentrations in groundwater, due to chemical leaching to groundwater, and measured VOC concentrations in groundwater was conducted to assess whether the existing VOC concentrations in soil may further degrade existing groundwater quality.

The SSL equation (Equation 1) was used to estimate maximum VOC concentrations in pore water by substituting the SSL parameter with maximum onsite soil concentrations in the equation to derive the maximum pore water concentration instead of the MCL:

$$C_{pw} = C_s / [(K_{oc} * f_{oc}) + ((O_w + O_a * H') / P_b)] \quad (\text{Equation 2})$$

Where:

$C_{pw}$  = maximum VOC concentration in pore water, mg/L; and  
 $C_s$  = maximum VOC concentration in soil, mg/kg.

The estimated maximum VOC concentration in groundwater was then derived by applying the soil attenuation factor of 3 and the EPA DAF of 20 to the maximum pore water concentration. The resulting estimated maximum VOC concentrations in groundwater are presented in Table F-5. In Table F-6, these concentrations are compared to the measured VOC concentrations in groundwater from the closest groundwater monitoring well(s) on or in proximity to the subject parcel.

As shown in Table F-6, the estimated maximum groundwater concentrations for chloroform, PCE, and methylene chloride are all less than the most recently measured concentrations for groundwater samples collected from the monitoring well situated closest to the borings with the greatest onsite soil concentrations of these chemicals. Since, the VOC concentrations from these measured groundwater samples do not pose health risks greater than acceptable levels (see Table F-1), the estimated maximum groundwater concentrations would also not pose health risks greater than acceptable levels from inhalation of indoor air due to vapor migration from groundwater into indoor air.

## **CUMULATIVE HUMAN HEALTH RISKS**

As indicated in the previous sections, the following additional potential exposure pathways were evaluated after incorporating the January 2001 investigation results:

- inhalation of VOCs in indoor air from upward VOC vapor migration from deep soil into onsite buildings
- inhalation of VOCs in indoor air from upward VOC vapor migration from groundwater into onsite buildings
- inhalation of VOCs in indoor air due to VOC migration from deep soil leachate migration to groundwater and subsequent VOC vapor migration from groundwater into indoor air

The risks associated with the above-listed exposure pathways, and the estimated risks to potential onsite receptors as presented in the post-demolition risk assessment are summarized in Table F-7. As shown in Table F-7, adding the estimated risks from the above-listed pathways to the estimated risks to the potential on-site receptors do not result in risks greater than the OEHHA-approved acceptable risk levels.

**Table F-1**  
**Summary of Risk Associated with VOC Vapor Migration from Groundwater**

Chemical	Closest Groundwater Monitoring Well	Most Recent Date Sampled	Groundwater Monitoring Well Concentration (mg/L)	Excess Cancer Risk	Estimated Hazard Index
Chloroform	XMW-09	October 12, 2000	1.500*	$3.8 \times 10^{-8}$	0.000061
PCE	XMW-09	October 12, 2000	0.055*	$5.2 \times 10^{-9}$	0.000070
Methylene chloride	TMW-12	January 25, 2001	0.004**	$1.1 \times 10^{-11}$	0.000000077
Total				$4.3 \times 10^{-8}$	0.00013

\* Data obtained from K/J from groundwater sample collected on October 12, 2000 (laboratory report presented in Appendix B).

\*\* Methylene chloride results for groundwater sample collected from XMW-09 on October 12, 2000 was <0.005 mg/L. Groundwater monitoring wells located downgradient of XMW-09 include TMW-11 through TMW-14 and TMW-18. During the most recent groundwater sampling event (January 25, 2001), TWM-14 exhibited a methylene chloride concentration of 0.004 mg/L (laboratory report presented in Appendix C).

Table F-2. Site-specific Geotechnical Parameters at the BRC Former C-6 Facility

Sample ID	Date Sampled	Depth (feet bgs)	Sieve Analysis (Soil Type)	Dry Bulk Density (kg/L)	Moisture Content (percent by weight)	Total Porosity (fraction by volume)	Air-filled Porosity (fraction by volume)	Water-filled Porosity (fraction by volume)	TOC* (mg/kg)	f <sub>oc</sub> (fraction by weight)
EIA290176-001 (I-34-5)	1/29/2001	5	Silt	1.51	15.9	0.43	0.19	0.24	520	0.0005
EIA290176-010 (D-29-5)	1/29/2001	5	Silt	1.44	20.3	0.46	0.16	0.29	2350	0.0024
EIA29176-018 (I-25-5)	1/29/2001	5	Silt	1.34	17.8	0.49	0.26	0.24	690	0.0007
<b>Average</b>				<b>1.43</b>	<b>18.0</b>	<b>0.46</b>	<b>0.20</b>	<b>0.26</b>	<b>1187</b>	<b>0.0012</b>
EIA290176-004 (I-34-20)	1/29/2001	20	Silt	1.54	17.5	0.42	0.15	0.27	330	0.0003
EIA290176-012 (D-29-20)	1/29/2001	20	Silt	1.55	17.0	0.41	0.15	0.26	430	0.0004
EIA29176-021 (I-25-20)	1/29/2001	20	Silt	1.37	20.2	0.48	0.20	0.28	410	0.0004
<b>Average</b>				<b>1.49</b>	<b>18.2</b>	<b>0.44</b>	<b>0.17</b>	<b>0.27</b>	<b>390</b>	<b>0.0004</b>
EIA290176-007 (I-34-50)	1/29/2001	50	Fine sand	1.35	4.4	0.51	0.45	0.06	230	0.0002
EIA29176-015 (D-29-50)	1/29/2001	50	Fine sand	1.36	19.5	0.49	0.22	0.26	560	0.0006
EIA29176-024 (I-25-50)	1/29/2001	50	Silt	1.34	24.3	0.51	0.18	0.32	470	0.0005
<b>Average</b>				<b>1.35</b>	<b>16.1</b>	<b>0.50</b>	<b>0.28</b>	<b>0.22</b>	<b>420</b>	<b>0.0004</b>

**Weighted Fraction by weight (depths 25 to 65 feet bgs)**

1.44

0.46

0.21

0.25

0.0004

The weighted fraction by weight assumes the 5-foot sample is representative of the top 20 feet, the 20-foot sample of depths between 20 and 50 feet, and the 50-foot sample of depths between 50 and 65 feet bgs.

Notes:

The air-filled porosity values were calculated from gravimetric data, not volumetric data.

\* f<sub>oc</sub> = the weight fraction of organic carbon in soil = TOC/1,000,000

Table F-3. Soil Particle Size Distribution at BRC Former C-6 Facility

Sample ID	Date Sampled	Depth (feet bgs)	Sieve Analysis (Soil Type)	Median Grain Size (mm)	Particle Size Distribution, wt. Percent					
					Gravel	Sand Size			Silt	Clay
						Coarse	Medium	Fine		
EIA290176-001 (I-34-5)	1/29/2001	5	Silt	0.029	0.00	0.00	0.22	17.60	69.80	12.37
EIA290176-010 (D-29-5)	1/29/2001	5	Silt	0.027	0.00	0.00	0.02	17.00	68.41	14.58
EIA29176-018 (I-25-5)	1/29/2001	5	Silt	0.026	0.00	0.00	0.39	14.86	68.78	15.97
<b>Average</b>									<b>69.00</b>	<b>14.31</b>
EIA290176-004 (I-34-20)	1/29/2001	20	Silt	0.032	0.00	0.00	0.00	31.19	54.83	13.99
EIA290176-012 (D-29-20)	1/29/2001	20	Silt	0.036	0.00	0.00	0.90	27.59	59.67	11.85
EIA29176-021 (I-25-20)	1/29/2001	20	Silt	0.020	0.00	0.00	0.00	11.21	69.07	19.72
<b>Average</b>									<b>61.19</b>	<b>15.19</b>
EIA290176-007 (I-34-50)	1/29/2001	50	Fine sand	0.151	0.00	0.00	0.57	79.33	17.39	2.71
EIA29176-015 (D-29-50)	1/29/2001	50	Fine sand	0.083	0.00	0.00	3.26	47.93	39.79	9.01
EIA29176-024 (I-25-50)	1/29/2001	50	Silt	0.027	0.00	0.00	0.04	21.27	64.99	13.70
<b>Average</b>									<b>40.72</b>	<b>8.47</b>

Weighted Fraction by weight (depths 25 to 65 feet bgs)

0.34	0.54	0.13
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The weighted fraction by weight assumes the 5-foot sample is representative of the top 20 feet, the 20-foot sample of depths between 20 and 50 feet, and the 50-foot sample of depths between 50 and 65 feet bgs.

Table F-4. Comparison of Maximum Soil Concentrations to Site-specific SSLs Calculated at 25 Feet Below Ground Surface

CAS No.	Chemical	MCL (mg/L)	$K_{oc}^{(1,2)}$	$f_{oc}^{(3)}$	$K_d^{(4)}$	$H^*(1)$	$O_w^{(3)}$	$O_a^{(3)}$	$P_b^{(3)}$	Max. Residual Soil Concentration (mg/kg)	AF at D=40'	Site-specific SSL (mg/kg) at AF at D=40'	Site-specific SSL (mg/kg) at AF at D=40' and DAF=20	Max > SSL for at AF <sub>r</sub> at D=40' and DAF=20?
67-66-3	Chloroform	na	--	--	--	--	--	--	--	3.30E-01	3	9.57E-04	2.70E-03	No
75-09-2	Methylene Chloride	5.00E-03	1.0E+01	4.01E-04	--	9.0E-02	2.50E-01	2.12E-01	1.44E+00	6.80E-03	3	1.97E-03	5.54E-03	No
127-18-4	Tetrachloroethene	5.00E-03	2.7E+02	4.01E-04	--	7.5E-01	2.50E-01	2.12E-01	1.44E+00	4.70E-02	3	1.97E-03	1.11E-01	No

An SSL was not derived for chemicals that do not have promulgated primary MCLs. These chemicals were not included in the assessment of potential further degradation to groundwater quality.

AF = Average attenuation factor based on site lithology (distance to groundwater = 40 feet, 34% sand, 53% silt, and 13% clay).

na = not available

$K_{oc}$  = soil organic carbon-water partition coefficient (L/kg)

$f_{oc}$  = site-specific organic carbon content of soil (kg/kg)

$K_d$  = soil-water partition coefficient (L/kg),  $K_{oc} \times f_{oc}$

$H^*$  = dimensionless Henry's law constant

$O_w$  = site-specific average water-filled porosity (by volume)

$O_a$  = site-specific average air-filled porosity (by volume)

$P_b$  = dry soil bulk density (kg/L)

(1) Obtained from EPA Region 9 preliminary remediation goal (PRG) physical-chemical data for volatile organic compounds, November 2000

(2) Obtained from Risk Assessment Information System (RAIS) Toxicity & Chemical-Specific Factors Data Base, January 2001, [http://risk.lsd.ornl.gov/cgi-bin/tox/tox\\_select?select=csf](http://risk.lsd.ornl.gov/cgi-bin/tox/tox_select?select=csf)

(3) Site-specific average values

(4) Obtained from EPA Soil Screening Guidance: Technical Background Document (TBD), EPA/540/R-95/128, July 1996, <http://www.epa.gov/oeppage/superfund/resources/soil/toc.htm>

Table F-5. Derivation of Estimated Maximum VOC Concentrations in Groundwater at Parcel D Using a Site-specific SSL Equation

CAS No.	Chemical	Max. Residual Soil Concentration (mg/kg)	95%UCL Residual Soil Concentration (mg/kg)	$K_{oc}^{(1)}$	$f_{oc}^{(2)}$	$K_d^{(3)}$	$H'^{(1)}$	$O_w^{(2)}$	$O_a^{(2)}$	$P_b^{(2)}$	Pore Water Conc. (mg/L)	Groundwater Conc. (mg/L) = Pore Water Conc. / AF / DAF
67-66-3	Chloroform	3.30E-01	4.31E-02	5.3E+01	4.01E-04	--	1.5E-01	2.50E-01	2.12E-01	1.44E+00	1.5E+00	2.5E-02
127-18-4	Tetrachloroethene	4.70E-02	8.60E-03	2.7E+02	4.01E-04	--	7.5E-01	2.50E-01	2.12E-01	1.44E+00	1.2E-01	2.0E-03
75-09-2	Methylene chloride	6.80E-03	--	1.0E+01	4.01E-04	--	9.0E-02	2.50E-01	2.12E-01	1.44E+00	3.6E-02	5.9E-04

$K_{oc}$  = soil organic carbon-water partition coefficient (L/kg)  
 $f_{oc}$  = organic carbon content of soil (kg/kg)  
 $K_d$  = soil-water partition coefficient (L/kg),  $K_{oc} \times f_{oc}$   
 $H'$  = dimensionless Henry's law constant  
 $O_w$  = site-specific average water-filled porosity (by volume)  
 $O_a$  = site-specific average air-filled porosity (by volume)  
 $P_b$  = dry soil bulk density (kg/L)

<sup>(1)</sup> Obtained from EPA Region 9 preliminary remediation goal (PRG) physical-chemical data for volatile organic compounds, November 2000

<sup>(2)</sup> Site-specific average values

<sup>(3)</sup> Obtained from EPA Soil Screening Guidance: Technical Background Document (TBD), EPA/540/R-95/128, dated July 1996, <http://www.epa.gov/oerrpage/superfund/resources/soil/toc.htm>

**Table F-6**  
**Comparison of Estimated VOC Concentrations in Groundwater to Measured VOC**  
**Concentrations in Groundwater**

Chemical	Maximum Soil Concen- tration (mg/kg)	Estimated Maximum Potential Groundwater Concentration (mg/L)	Closest Groundwater Monitoring Well	Most Recent Date Sampled	Closest Groundwater Monitoring Well Concentration (mg/L)*
Chloroform	0.330	0.025	XMW-09	October 12, 2000	1.500**
PCE	0.047	0.0020	XMW-09	October 12, 2000	0.055
Methylene chloride	0.0068	0.00059	XMW-09	October 12, 2000	< 0.005**

\* Data obtained from K/J from groundwater sample collected on October 12, 2000 (laboratory report presented in Appendix B).

\*\* Groundwater monitoring wells located downgradient of XMW-09 include TMW-11 through TMW-14 and TMW-18. During the most recent groundwater sampling event (January 25, 2001), TMW-12 exhibited a chloroform concentration of 1.5 mg/L, and TWM-14 exhibited a methylene chloride concentration of 0.004 mg/L (laboratory report presented in Appendix C).

Table F-7. Summary of Cumulative Risks

	Onsite Construction Worker	Onsite Commercial/Industrial Worker	Onsite DTSC Commercial/Industrial Worker
<b>Hazard Index</b>			
Previously Estimated	0.13	0.0000069	0.011
Vapor Migration from Deep Soil	NA	0.0000022	0.0000022
Vapor Migration from Groundwater	NA	0.00013	0.00013
Vapor Migration from Deep Soil			
Leachate and Subsequent Volatilization from Groundwater	NA	No additional risk	No additional risk
<b>Total</b>	0.13	0.00014	0.011
<b>Excess Cancer Risk</b>			
Previously Estimated	8.5E-07	4.7E-10	1.8E-06
Vapor Migration from Deep Soil	NA	7.7E-10	7.7E-10
Vapor Migration from Groundwater	NA	4.3E-08	4.3E-08
Vapor Migration from Deep Soil			
Leachate and Subsequent Volatilization from Groundwater	NA	No additional risk	No additional risk
<b>Total</b>	8.5E-07	4.4E-08	1.8E-06

NA = Not applicable